PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
103372501		
International application No. PCT/SE00/00043	International filing date *(day month year)* 13.01.2000	Priority date *(day month year)* 15.01.1999
International Patent Classification (IPC) or national classification and IPC B25J 9/16		
Applicant ABB AB et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
01.08.2000	10.07.2001
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Telex: 17978 PATOFF-S Facsimile No. 08-667 72 88	Authorized officer Sture Elnäs /OGU Telephone No. 08-782 25 00

Form PCT/IPEA/409 (cover sheet) (January 1998)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SE00/00043

I. Basis of the report

1. With regard to the elements of the international application:*

☒ the international application as originally filed

☐ the description:
pages 1-7 , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

☒ the claims:
pages _____ , as originally filed
pages _____ , as amended (together with any statement) under article 19
pages _____ , filed with the demand
pages 8-9 , filed with the letter of 04.05.2001

☒ the drawings:
pages 1-4 , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

☐ the sequence listing part of the description:
pages _____ , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language English which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
☒ the language of publication of the international application (under Rule 48.3(b)).
☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.
☐ filed together with the international application in computer readable form.
☐ furnished subsequently to this Authority in written form.
☐ furnished subsequently to this Authority in computer readable form.
☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:
☐ the description, pages _____
☐ the claims, Nos. _____
☐ the drawings, sheet/fig _____

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2 (c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SE00/00043

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-10	YES
	Claims		NO
Inventive step (IS)	Claims		YES
	Claims	1-10	NO
Industrial applicability (IA)	Claims	1-10	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

The claimed invention relates to a method and a device for synchronizing an industrial robot. In this application, synchronizing refers to checking the zero-position, or setting at the zero-position of an axle.

The invention is intended to solve the problem of time-consuming recalibration/synchronization of the robot after maintenance or shutdowns.

The solution according to the invention comprises detection of at least two distinct detectable step-like changes of a notch or a tooth. A sensor detects the angular position of the flanks and the position of the target is calculated and introduced into the control device. The position of the target is compared with a calibration position.

Documents cited in the International Search Report:

D1: US 4419831
D2: US 4806066
D3: EP 0166002
D4: US 4816955

The cited documents each describe methods used on industrial robots for associating two mechanical elements to each other by the detection of an angular position of the members.

D1 teaches angular detection comprising a notch that is at an elevation distinct from the remaining area of the shaft. A contact sensor indicates the notch.

D2 discloses a method and an apparatus where a reference or a home position can be checked. Mispositioning of the members can be determined upon power-up or periodically by counting

.../...

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SE00/00043

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Box V.

the number of steps required to position into a home position. Furthermore, a comparison with a theoretical number is made followed by correction of the mispositioning (column 10, line 3-14). The sensor disclosed is a non-contact sensor comprising a light beam entering a gap. Blocking the light beam indicates the position. Other sensors are suggested (figures 7a and b, column 10, line 15-45).

D3 discloses recesses for aligning arms at an industrial robot. The recesses are step-like changes.

D4 discloses an arrangement that provides a sensor for scanning a joint-zero position of robot axles. An inductive sensor senses step-like changes of an opposite surface. The signals are fed to the program control (column 3, line 47-58, claim 4 and 15, figure1).

D2 is closest to describing the invention. D2 and the invention each disclose a solution for the same problem; checking position upon restart or periodically during operation and comparing with a calibrated value. The invention differs from the method and the device disclosed in D2 in that the position is determined by detecting at least two step-like changes while passing them. The objective problem is therefore to find an alternative method for detecting the position.

Using teeth or notches for contact or non-contact angular detection is well known to a person skilled in the art. These devices are commonly used for measuring angular speed as well as the position of axles. D3 as well as D4 show these devices on robots. D4 also teaches scanning the changes of the target and describes detection of one step. However, two steps are indicated in figure 1 of D4 and detecting two steps as in the invention does not involve any unexpected technical effect.

Consequently, it is obvious to a person skilled in the art to use step-like changes and sensors, either contact or non-contact, for angular detection of the arms at an industrial robot.

As to the matter that the device and method are intended for synchronizing the robot in the meaning to check the zero-position, or set at the zero-position of an axle, it is described in D2 that a sensor may be used to check any mispositioning between the structural member. This may be done

.../...

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SE00/00043

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Box V.

upon initial power-up or periodically during the operation. Furthermore, it is described that the position errors are used to correct the mispositioning.

By combining the information from D2 and the information from D3 or preferably D4, it is obvious to a person skilled in the art to arrange a method and a device as claimed in claims 1-10.

Accordingly, the invention as claimed in claims 1-10 fulfills the requirements of novelty (N). It does not fulfill the requirement of inventive step (IS) but is industrially applicable (IA).

PCT/SE 00/00043
04 -05- 2001

CLAIMS

1. Method for synchronising a robot (1) that includes a control system (2), a first robot part (3) and a second robot part (5) movably attached to the first robot part (3), whereby the position of a target (4) arranged on the first robot part (3) is determined by the passage of a sensor (6) arranged on the second robot part (5) characterised in that the target (4) is caused to include several distinct detectable changes (4a, 4b) comprising step-like structural changes, that at least two of these distinct detectable changes (4a, 4b) are sensed by the sensor (6), that the position (4c) of the target (4) is calculated and that the calculated target position is introduced into the control system and compared with a calibration position for the target (4) in the control system.

2. Method according to claim 1 characterised in that the position of the target (4) is read with a sensor (6) in the form of a non-contact sensor.

3. Method according to claim 1 characterised in that the position of the target (4) is read with a sensor in the form of a contact sensor.

4. Method according to any of the previous claims characterised in that the target (4) is designed as a groove with essentially vertical walls (4a) and (4b).

5. Method according to claim 1 characterised in that the target (4) is designed as an elevation with essentially vertical sides (4a') and (4b').

6. Device for synchronising a robot (1) that includes a control system (2), a first robot part (3) and a second robot part (5) movably attached to the first robot part (3) where the device includes a target (4) arranged on the first robot part (3) and a sensor (6) arranged on the second robot part (5) characterised in that the target (4) includes several distinct by the sensor (6) detectable changes (4a, 4b) comprising step-like structural changes.

7. Device according to claim 6 characterised in that the step-like structural changes comprise instantaneous level differences in the form of shoulder parts (7).

AMENDED SHEET

8. Device according to claim 6 characterised in that the target (4) is designed as a groove with essentially vertical walls (4a) and (4b).

9. Device according to claim 6 characterised in that the target (4) is designed as an elevation with essentially vertical sides (4a) and (4b).

10. Use of a method according to any of claims 1-5 or device according to any of claims 7-9 for an industrial robot.

AMENDED SHEET

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 103372501	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/SE 00/00043	International filing date *(day/month/year)* 13 January 2000	(Earliest) Priority Date *(day/month/year)* 15 January 1999
Applicant ABB AB et al		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] Certain claims were found unsearchable (See Box I).

2. [ ] Unity of invention is lacking (See Box II).

3. [ ] The international application contains disclosure of a nucleotide and/or amino acid sequence listing and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] transcribed by this Authority.

4. With regard to the title,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the abstract,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is:
   Figure No. 2
   - [X] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/00043

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B25J 9/16
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B25J, B23Q, G01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4419831 A (E. ZIMMER), 13 December 1983 (13.12.83), column 2, line 31 - line 56, figure 1	1-4,7,11
A	US 4806066 A (G.W. RHODES ET AL), 21 February 1989 (21.02.89), column 9, line 58 - column 13, line 16, figures 7a,7b	1-11
A	EP 0166002 A1 (FANUC LTD), 2 January 1986 (02.01.86), page 5, line 21 - page 6, line 9, figures 1-3, abstract	1-11

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
10 April 2000

Date of mailing of the international search report
10 -05- 2000

Name and mailing address of the ISA
Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer
Anna Sandberg / MR
Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/00043

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4816955 A (J. BRUNS ET AL), 28 March 1989 (28.03.89), column 3, line 47 - line 58, figures 1-3, abstract -- --------	1-11

INTERNATIONAL SEARCH REPORT
Information on patent family members

02/12/99

International application No.
PCT/SE 00/00043

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4419831 A	13/12/83	DE 2825581 A	13/12/79
		EP 0006160 A,B	09/01/80
		SE 0006160 T3	
		ES 481241 A	16/11/79
		JP 54162565 A	24/12/79
US 4806066 A	21/02/89	AU 2079683 A	22/05/84
		EP 0124540 A	14/11/84
		FI 842665 A	02/07/84
		IL 69862 A	30/09/86
		WO 8401740 A	10/05/84
EP 0166002 A1	02/01/86	JP 60127985 A	08/07/85
		WO 8502575 A	20/06/85
US 4816955 A	28/03/89	DE 3522337 A	05/02/87
		EP 0226594 A,B	01/07/87
		SE 0226594 T3	
		JP 63500648 T	10/03/88
		WO 8607556 A	31/12/86

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

AB Stockholms Patentbyrå,
Zacco & Bruhn
Box 23101
104 35 STOCKHOLM

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of mailing *(day/month/year)*	21-12-2000
Applicant's or agent's file reference: 103372501 CFO	REPLY DUE: within 45 days from the above date of mailing

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/SE00/00043	13.01.2000	15.01.1999

International Patent Classification (IPC) or both national classification and IPC: B 25 J 9/16

Applicant: ABB AB et al

1. This written opinion is the First (first, etc.) drawn by this International Preliminary Examining Authority.
2. This opinion contains indications relating to the following items:
   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application
3. The applicant is hereby **invited to reply** to this opinion.
   - **When?** See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).
   - **How?** By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.
   - **Also** For an additional opportunity to submit amendments, see Rule 66.4. For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4*bis*. For an informal communication with the examiner, see Rule 66.6.

   If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.
4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 15.05.2001

Name and mailing address of the IPEA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Telex 17978 PATOREG-S Facsimile No. 08-667 72 88	Sture Elnäs/MN Telephone No. 08-782 25 00

Form PCT/IPEA/408 (cover sheet) (January 1998)

WRITTEN OPINION

Inte[redacted]nal application No.
PCT/SE00/00043

I. Basis of the opinion

1. With regard to the **elements** of the international application:*

☒ the international application as originally filed

☐ the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☐ the claims:
pages _____, as originally filed
pages _____, as amended (together with any statement) under article 19
pages _____, filed with the demand
pages _____, filed with the letter of _____

☐ the drawings:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☐ the sequence listing part of the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language English which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☒ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the written opinion was drawn on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages _____

☐ the claims, Nos. _____

☐ the drawings, sheet/fig _____

5. ☐ This opinion has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2 (c)).

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed".*

WRITTEN OPINION

International application No.
PCT/SE00/00043

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-11	YES
	Claims		NO
Inventive step (IS)	Claims	~~1-11~~	YES
	Claims	1-11	NO
Industrial applicability (IA)	Claims	1-11	YES
	Claims		NO

2. Citations and explanations

The claimed invention relates to a method and a device for synchronizing an industrial robot. Synchronizing refers to checking or setting the zero-position of an axle.

The invention is intended to solve the problem of time-consuming recalibration of the robot after maintenance or shutdowns.

The solution according to the invention comprises detection of at least two distinct flanks of a notch or a tooth. The angular position of the flanks are detected and used by the control device.

Documents cited in the International Search Report:

US 4419831 X
EP 0166002 A

Cited documents describe a method for associating two mechanical elements to each other. US 4419831 teaches angular detection comprising a notch which is at an elevation distinct from the remaining area of the shaft. EP 0166002 discloses recesses for aligning arms at an industrial robot.

Using teeth or notches for non-contact angular detection is well known to a person skilled in the art. These devices are commonly used for measuring angular speed as well as the position of axles.

From US 4419831 a method and a device for aligning the position at an industrial robot are known. The method comprises a feeler in contact with the shaft.

.../...

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: V

The subject matter claimed differs from the apparatus described in the cited US 4419831
in respect of using grooves or teeth with step-like flanks in calibrating robots. However, the use of recesses at robots is known from EP 0166002. By combining the information from the cited documents it is obvious to a person skilled in the art to arrange a method and a device as claimed. The method and device according to claims 1-11 are therefore considered not to involve an inventive step.

Accordingly, the invention, as claimed in claims 1-11 does not fulfill the requirements of inventive step (IS).

ZACCO

STOCKHOLMS PATENTBYRÅ ZACCO

P.ans.nr : PCT/SE00/00043

Till
INTERNATIONELLA SEKTIONEN
Patent- och registreringsverket
STOCKHOLM

Internationell patentansökan nr PCT/SE00/00043

Innehavare: ABB AB

Svaromål i den internationella patentansökan PCT/SE00/00043 med titeln – "Method for an industrial robot" och sökande ABB AB

Med anledning av telefonsamtal med PRVs granskare vill vi anföra följande:

Härmed lämnar vi in nya patentkrav 1-10 vilka ska ligga till grund för den fortsatta handläggningen.

Patentkrav 1 har tillförts texten "att åtminstone två av dessa distinkt detekterbara förändringar" vilket har stöd i grundhandlingarna, se till exempel sidan 4, rad 6.
Patentkrav 1 har även tillförts texten "och jämförs med ett kalibreringsläge för målet (4) i styrsystemet" vilket har stöd i grundhandlingarna, se till exempel sidan 6, rad 18-20.

I övrigt har de andra patentkravens hänvisningar anpassats till den nya numreringen.

Granskaren meddelade vid ett telefonsamtal att vår uppfinning enligt de senast inlämnade patentkraven (inlämnade 2000-02-12) fortfarande bedöms sakna uppfinningshöjd.

Handlägges av : Maria Lundström
Aktnummer : 103372501 PC
Tel nr : 0910 – 88 100

Vi har nu genom ytterligare omformulering av patentkraven försökt att precisera de tydliga skillnader som finns mellan vår uppfinning och de konstruktioner och förfaranden som beskrivs i de anförda dokumenten.

Kalibrering, med betydelsen att initiera en robots konfiguration vid igångsättning och med syftet att finna robotens exakta konfiguration (0-läge / kalibreringsläge) vid tiden för kraftpåslag och initiera den kontrollerande delen av styrsystemet i enlighet därmed, sker innan start av robotens arbete.

Robotens arbete kan av olika anledningar komma att avbrytas eller störas. Ibland innebär ett stopp eller en störning av robotens arbete att robotens delar förflyttas så mycket i förhållande till varandra att den ursprungliga konfigurationen och styrsystemsinställningen inte längre går att använda. Det vanliga är att en ny kalibrering görs efter ett stopp. Kalibrering är dock tidsödande och kräver att en operatör är närvarande.

Vår uppfinning avser en metod, en anordning och användning av lägesmätning vid synkronisering av en robot efter ett avbrott eller en störning av robotens arbete för att kunna bestämma om ny kalibrering är nödvändig eller om robotens arbete kan fortsätta. Syftet med vår uppfinning är att snabbt, enkelt och med hög noggrannhet kunna synkronisera en robot. "Synkronisering" avser i denna ansökan kontroll eller inställning av roboten mot 0-läget / kalibreringsläget efter serviceuppehåll, tex motorbyte, driftsstopp, sammanstötning och dylikt.

Lösningen enligt uppfinningen ligger i att anordna ett fysiskt mål på den rörliga delen av roboten vid respektive robotaxlar och vid förflyttning av den rörliga delen fram och tillbaka med en givare avläsa åtminstone två med rörelsen åtskilda distinkta lägen hos målet, beräkna målets läge och införa värdet för läget i styrsystemet och jämföra detta med ett under kalibreringen erhållet läge för målet som också finns i styrsystemet. Det fysiska målet är utformat med två eller flera distinkta detekterbara förändringar som utgörs av språngvisa strukturförändringar.

Vi anser, precis som granskaren, att vår uppfinning är ny i förhållande till vad som är förut känd genom de anförda dokumenten. Vi anser även att vår uppfinning har uppfinningshöjd.

Inget av de anförda dokumenten tar upp problemet med att minimera tiden för en robots driftsstopp och inget av de anförda dokumenten visar en metod för att synkronisera en robot, där synkronisera har den betydelse som vi har preciserat i vår beskrivning, eller en anordning som gör detta möjligt som motsvarar vår uppfinning.

Inget av de anförda dokumenten visar heller en anordning motsvarande vår som innefattar ett mål och sensor som har den konstruktion som finns hos vår uppfinning och som arbetar med den metod som vår uppfinning innefattar.

Det finns inget i de anförda dokumenten som skulle leda en fackman till en metod, anordning eller en användning som motsvarar vår uppfinning. Vi anser att det inte är närliggande för fackmannen att mot bakgrund av det anförda dokumentet utforma en metod för synkronisering av en robot med en anordning innefattande ett flertal av en sensor distinkt detekterbara förändringar enligt vår uppfinning.

Sammanfattningsvis anser vi att föreliggande uppfinning är ny och att den uppvisar uppfinningshöjd i jämförelse med de anförda dokumenten. Även det som framgår av underkraven utgör fördelaktiga utföringsformer enligt föreliggande uppfinning, vilka mot bakgrund av de självständiga kraven 1, 6 och 10 utgör bestämningar, som motiverar patentskydd.

Om granskaren fortfarande är av annan uppfattning avseende patenterbarheten hos vår uppfinning och eventuellt slutgiltigt beslut går oss emot vill vi att granskaren tar kontakt med oss via vårt ombud innan beslut fattas.

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CLAIMS

1. Method for synchronising a robot (1) that includes a control system (2), a first robot part (3) and a second robot part (5) movably attached to the first robot part (3), whereby the position of a target (4) arranged on the first robot part (3) is determined by the passage of a sensor (6) arranged on the second robot part (5) c h a r a c t e r i s e d in that the target (4) is caused to include several distinct detectable changes (4a, 4b) comprising step-like structural changes, that at least two of these distinct detectable changes (4a, 4b) are sensed by the sensor (6), that the position (4c) of the target (4) is calculated and that the calculated target position is introduced into the control system and compared with a calibration position for the target (4) in the control system.

2. Method according to claim 1 c h a r a c t e r i s e d in that the position of the target (4) is read with a sensor (6) in the form of a non-contact sensor.

3. Method according to claim 1 c h a r a c t e r i s e d in that the position of the target (4) is read with a sensor in the form of a contact sensor.

4. Method according to any of the previous claims c h a r a c t e r i s e d in that the target (4) is designed as a groove with essentially vertical walls (4a) and (4b).

5. Method according to claim 1 c h a r a c t e r i s e d in that the target (4) is designed as an elevation with essentially vertical sides (4a′) and (4b′).

6. Device for synchronising a robot (1) that includes a control system (2), a first robot part (3) and a second robot part (5) movably attached to the first robot part (3) where the device includes a target (4) arranged on the first robot part (3) and a sensor (6) arranged on the second robot part (5) c h a r a c t e r i s e d in that the target (4) includes several distinct by the sensor (6) detectable changes (4a, 4b) comprising step-like structural changes.

7. Device according to claim 6 c h a r a c t e r i s e d in that the step-like structural changes comprise instantaneous level differences in the form of shoulder parts (7).

8. Device according to claim 6 c h a r a c t e r i s e d in that the target (4) is designed as a groove with essentially vertical walls (4a) and (4b).

9. Device according to claim 6 c h a r a c t e r i s e d in that the target (4) is designed as an elevation with essentially vertical sides (4a) and (4b).

10. Use of a method according to any of claims 1-5 or device according to any of claims 7-9 for an industrial robot.

PCT

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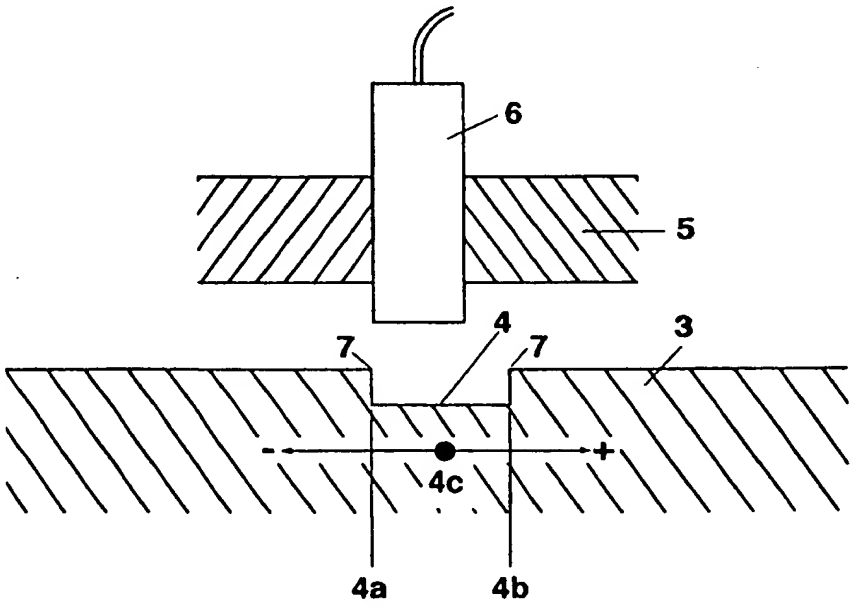
(57) Abstract

Method for synchronising a robot where a target is arranged on the movable part of the robot at the respective robot axles. The movable part rotates back and forth and at the same time a sensor reads at least two distinct detectable changes on the target. The centre–point for the target is calculated and introduced into the control system.



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Method for a robot

TECHNICAL FIELD

The present invention relates to method for, a device for, and the use of positional measurement during the synchronising of a robot.

BACKGROUND

During operation, an industrial robot has to meet high requirements regarding precision and accuracy. The industrial robot carries out defined reproducible movements over a program-controlled linkage system driven by means of electric motors. The dimensions of the movement of the individual driving groups is controlled and supervised by an electronic path-measurement system. The zero positions of the driving system and the path-measurement system must correspond and be set to correspond again should deviations occur. An industrial robot thus has a need for a device for the exact and reproducible setting of the motor-driven linkage system of the robot. It is necessary to calibrate a robot to fulfil the demands for precision and accuracy named above and, following periods of stoppage of production and after service, it is necessary to synchronise the robot in order to meet the demands named above.

Here, calibration refers to initiating a configuration of a robot at start-up. The aim is to find the exact configuration (zero-position / calibration position) of the robot at the time when turning on the power and initiate the verifying part of the control system accordingly.

Here, synchronisation refers to checking or setting the robot to the zero-position / calibration position following service stops (e.g. replacing a motor), stoppages of production, collision and the like.

Industrial robots working with high accuracy are equipped with servo-controlled motors. To check a motor, a sensor has to measure the exact position of the angle of the motor

axle in real time. In servo motors, positional information together with angular speed is used in a feedback system to clear differences between predetermined and actual positions. Positional information cannot be used to check the robot if the measurements do not reflect the actual position of the robot. The goal of calibration is thus to initiate measurements of its ''true/real'' values.

When working with industrial robots, the need thus arises for a method for positional measuring to be used when calibrating and synchronising a robot.

The American document US,A 4 419 831 specifies a device that allows calibration of a linkage system that can be brought to correspond accurately with the calibration of an electronic path-measuring system even after replacement of parts of the drive or path-measuring system respectively. In a moveable part of two associated linkage parts, a recess or an elevation is arranged, and in an associated second linkage part, a guide for a measuring sensor instrument is adjustably and fixably arranged, where the sensing element of the instrument indicates the calibration position / zero-position during relative movement of both the linkage parts by determining the minimum respectively maximum of the recess or elevation. The object of the measurement method is to get the possibility to use the same program following replacement of measuring system or manipulator.

Service stops and other shut-downs mean disturbance of production lines and non-production, which leads to large and unwanted costs. It is thus of greatest importance that the time for shut-downs is minimised. Since the robot must be calibrated / synchronised after every stoppage, it is important that this is carried out quickly. At the same time, it is of greatest importance that the method is simple, accurate and has good reproducibility. Thus, the need arises for an accurate, simple and quick method for positional measuring.

This need cannot be met by the method in the American patent.

SUMMARY OF THE INVENTION

A robot system includes several partial systems, among others manipulator and control system. The manipulator is defined as the linkage arms, joints, transmissions and driving means that are included in the mechanical arm. The control system generates movements of the manipulator by servo-steering of the individual driving means as well as defined movements through a control and interpolation model of the physical construction of the manipulator. In the following, the term ''robot'' relates to a robot system including, among other things, manipulator and control system as defined above.

During manufacture, the robot is provided with a computer program that includes stored co-ordinates that correspond to pre-programmed points in the surrounding space. The robot is designed so that an operator can press a key on a keyboard whereby signals go to the different parts of the robot and direct them to take up the pre-determined positions and adjust themselves accordingly. This can be described as the robot being configured to its zero position / calibration position.

The robot is configured to the calibration position as above. Then the robot is calibrated with, for example, an external method that gives calibration values for respective rotation axle, which comprise reference values that are fed into the control system and stored.

To fulfil the demands named above for an accurate position measuring of the robot, a first robot part is provided with a physical target. A second robot part movably attached at the first robot part includes a sensor. The movement between the robot parts is translational or rotational. The position of the target is detected with the help of the sensor, which gives the offset angle a.

An installed robot thus has a calibration value and an offset angle a stored for the respective axis of rotation. The robot can be started and driven until it for some reason is stopped / stops. When necessary actions have been taken and it is time to start the robot again, the synchronising position of the robot must be checked. This means that the calibration program is run, the robot adjusts itself to its zero position / calibration position and the position of the target is measured for the respective axis, an angle da is calculated and compared with the stored offset angle a.

The difference d between the angle da measured and the offset angle a is calculated and presented as the offset of TCP (Tool Centre Point). The calculated difference d is shown on the screen of a programming controller. The value of d is shown graphically on the screen and is compared with a pre-determined limit value. When the value of the difference lies under the limiting value, the robot is ready for operation. However, when the value of the difference exceeds the limit value, it means that the configuration of the robot no longer corresponds to the stored calibration values. In that situation, it is necessary to begin again by configuring and calibrating the robot with, for example, an external method to obtain new calibration values for the zero position. After that, one continues by measuring new offset angle a and so one according to that above.

The object of the present invention is thus to achieve a method with which one can quickly, simply and with great accuracy synchronise a robot.

The solution according to the invention is to arrange a physical target on the moveable part of the robot at the respective robot axles and during displacement of the moving part back and forth, read at least two by the movement separate and distinct positions of the target with a transmitter, calculate the centre position / mean value and introduce the value into the control system.

The term robot axle relates to the moving axles of the robot for one of the rotation or translation movements.

In the cited American document, the target is designed either as a V-shaped depression or elevation and the transmitter measures the equivalent minimum or maximum points. The designing of the target as a point involves certain disadvantages. A point is easy to damage. The contact transmitter and further handling of axles results in a certain wear of the point, which has a detrimental effect on the accuracy. In addition, the possibility for positionally measuring a target during translational movement is not stated.

Measuring the position of a point with a contact transmitter is difficult with regard to the techniques of measurement. A point has two flanks and with a contact transmitter, problems of sliding occur along one of the flanks irrespective of whether it is an elevation or a depression. A contact transmitter, which reads the position of the point of a pointed target as it passes the transmitter back and forth displays a value with built-in errors in measurement due to the difficulty partly in following the surface of the point and partly in deciding exactly where the point is located. A more blunted point reduces the problem of sliding but does not give such a clear point position to sense.

To measure the position of a point with a non-contact transmitter requires an expensive and complicated transmitter to achieve reliable measurement results. In addition, high demands on precision are made in the designing of the point, which leads to extra costs. Furthermore, the transmitter should have a comparatively larger field of reading to be able to read a point. The transmitter thus requires space in an already very tight and compact design.

To minimise the disadvantages named above, the present invention is arranged with targets designed with two or more distinct detectable changes. In the embodiment described below, the target is designed as a milled groove. A milled groove is built up of at least two step-like level differences in the form of shoulder parts.

To measure the position of a shoulder part with a non-contact transmitter is easy with regard to the techniques of measurement. Shoulder parts have step-like and transverse level changes that are easy to register with comparatively simple and cheap transmitters. Even with a contact transmitter, it is easy to measure the position of a shoulder part, which gives an instantaneous level change.

When the position for a groove is to be read and the shoulder parts of the groove pass back and forth in front of the transmitter, the transmitter reads the position of two opposite shoulder parts at each pass. In one measuring position, the level change is ascending and in the other measuring position, the level change is descending. From a techniques of measurement point of view, there are errors in measurement included in all measuring

equipment. By reading two positions and calculating the centre position according to the invention, the error of measuring decreases and the accuracy of measurement increases. The groove is arranged so that its walls extend in a direction at right angles to the direction of motion both during translational and rotational movement. The accuracy of measurement decreases if the direction of the walls of the groove does not form a right angle with the direction of motion.

Designing the target as a milled groove in accordance with the invention is furthermore simpler, cheaper and does not call for the same demands for precision in comparison with the pointed target in the American patent document. A milled groove resists wear in a very satisfactory manner. Another practical advantage is that the grooves of the respective axles need not be identical.

DESCRIPTION OF THE DRAWING

The invention will be explained in greater detail by describing an example of an embodiment with reference to the enclosed drawing, where;

Fig. 1 shows an industrial robot including a control system,

Fig. 2 shows a target in the form of a groove with two distinct delimiters plus a transmitter,

Fig. 3 shows a target in the form of an elevation with two distinct delimiters plus a transmitter,

Fig. 4 shows a graphical reproduction of the measured angles (a) and (da) in relation to the zero-position / calibration position.

DESCRIPTION OF EMBODIMENTS

An industrial robot 1 is equipped with a control system 2 (Fig. 1). The movable part 3 of the robot 1 is provided on the respective robot axle with a physical target 4 and on the part 5 accommodating the equivalent robot axle, a sensor 6 is arranged. The target 4 comprises a milled groove that has two essentially vertical walls, 4a and 4b. The grove is designed with two sharp level differences in the form of shoulder parts 7 (Fig. 2).

The device aims, as above, to check / measure a determined position 4c of target 4 on the moving part 3 of robot 1 in relation to a calibration value for the respective robot axle. By running a computer program for calibration fed into the control system, the program will instruct the moving part 3 to pass sensor 6 in one or the other direction of rotation at the same time as the sensor senses the position of the target by detecting the position of the two distinct detectable changes 4a and 4b, calculate the centre-point 4c between the two changes and generate a mean value of an angle, the offset angle a (Fig. 4).

Fig. 4 shows the calibration position / zero position 0 and the offset angle a. It also shows an angle da, measured as above, that is larger than the offset angle a. A difference between the measured angle da and the offset angle a means that something has happened with the configuration of the robot. Included finally, therefore, is to evaluate if this difference is acceptable or not, which is already described in the summary of the invention.

When the robot is calibrated or alternately synchronised, the calibration of all axles takes place one at a time. Alternatively, one can consider calibrating all at the same time.

ALTERNATIVE EMBODIMENTS

The device according to the invention can also be designed with the target arranged on the part that accommodates the robot axle and with the transmitter arranged on the moving part in the respective robot axle.

When evaluating whether the difference d is acceptable or not, the evaluation can be programmed into the control system so that the evaluation is done automatically. Either the go-ahead to start the robot will be given or the order to recalibrate it.

Instead of having permanent sensors at every robot axle, one can instead arrange a space, e.g. an opening to hang a separate sensor in.

The sensor can either be a contact sensor or a non-contact sensor.

The target can also be an elevation with at least two essentially vertical sides.

The distinct detectable changes of the target can comprise several step-like structural changes.

The moving part in the respective robot axle can, during the positional measuring, be displaced only in one direction. In this case, the measuring still gives almost an equivalent result as when the movable part is displaced back and forth.

CLAIMS

1 Method for synchronising a robot (1) that includes a control system (2), a first robot part (3) and a second robot part (5) movably attached to the first robot part (3), whereby the position of a target (4) arranged on the first robot part (3) is determined by the passage of a sensor (6) arranged on the second robot part (5) and is compared with a calibration position in the control system c h a r a c t e r i s e d in that the target (4) is caused to include several distinct detectable changes (4a) and (4b), that the distinct detectable changes are sensed by the sensor (6), that the position (4c) of the target is calculated and that the calculated value is introduced into the control system.

2 Method according to claim 1 c h a r a c t e r i s e d in that the distinct detectable changes comprise step-like structural changes.

3 Method according to claim 1 c h a r a c t e r i s e d in that the position of the target (4) is read with a sensor (6) in the form of a non-contact sensor.

4 Method according to claim 1 c h a r a c t e r i s e d in that the position of the target (4) is read with a sensor in the form of a contact sensor.

5 Method according to any of the previous claims c h a r a c t e r i s e d in that the target (4) is designed as a groove with essentially vertical walls (4a) and (4b).

6 Method according to claim 1 c h a r a c t e r i s e d in that the target (4) is designed as an elevation with essentially vertical sides (4a´) and (4b´).

7 Device for synchronising a robot (1) that includes a control system (2), a first robot part (3) and a second robot part (5) movably attached to the first robot part (3) where the device includes a target (4) arranged on the first robot part (3) and a sensor (6) arranged on the second robot part (5) c h a r a c t e r i s e d in that the target (4) includes several distinct by the sensor (6) detectable changes.

8 Device according to claim 7 c h a r a c t e r i s e d in that the distinct detectable changes comprise instantaneous level differences in the form of shoulder parts (7).

9 Device according to claim 7 c h a r a c t e r i s e d in that the target (4) is designed as a groove with essentially vertical walls (4a) and (4b).

10 Device according to claim 7 c h a r a c t e r i s e d in that the target (4) is designed as an elevation with essentially vertical sides (4a) and (4b).

11 Use of a method according to any of claims 1-6 or device according to any of claims 7-10 for an industrial robot.

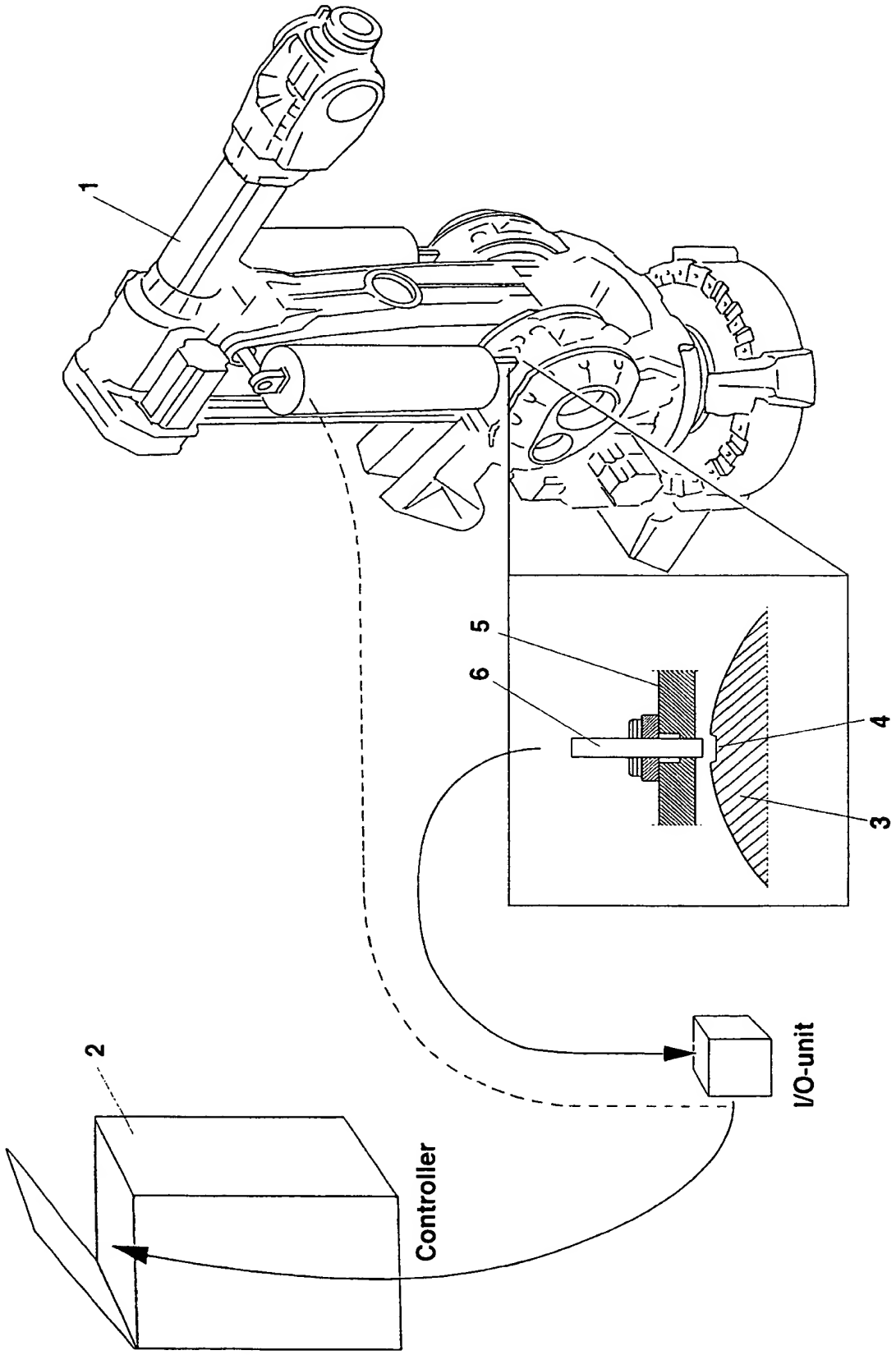

Fig. 1

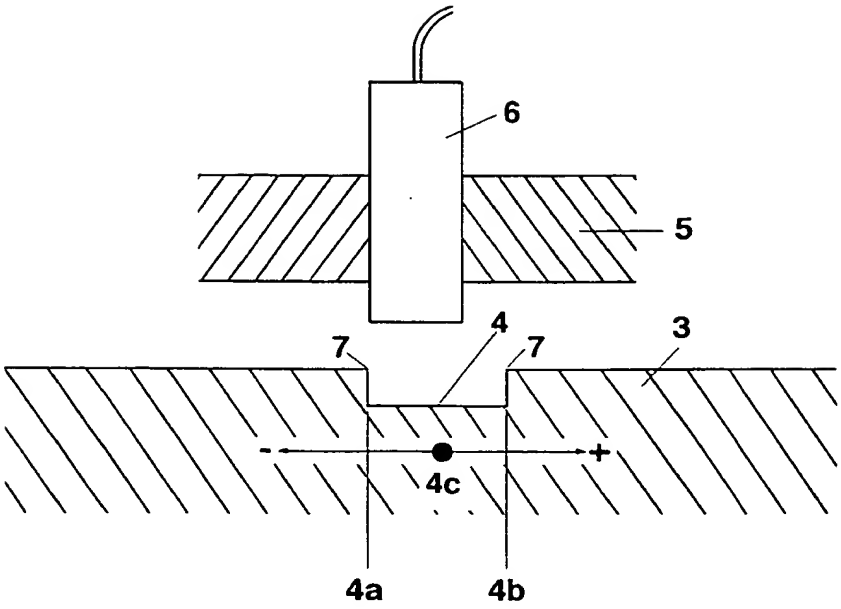

Fig. 2

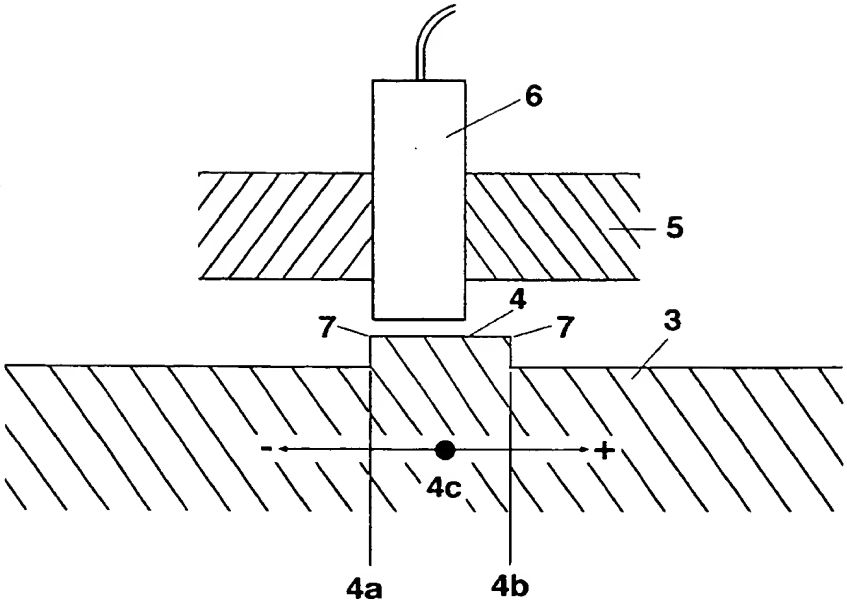

Fig. 3

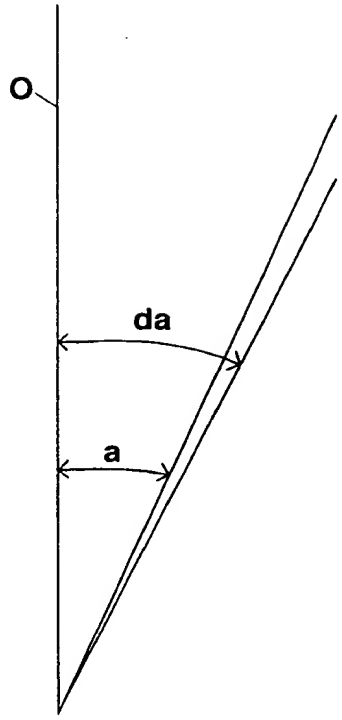

Fig. 4

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REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

International Application No.

International Filing Date 13-01-2000

The Swedish Patent Office
PCT International Application

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* 103372501

Box No. I TITLE OF INVENTION

Method for robot

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no state of residence is indicated below.)*

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Facsimile No.

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State *(that is, country)* of residence: Sweden

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

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☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

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This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below ~~is hereby~~/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

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Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTORS

If none of the following sub-boxes is used, this sheet is not to be included in the request.

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This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: Sweden

State *(i.e. country)* of residence: Sweden

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no state of residence is indicated below.)*

This person is:

☐ applicant only

☐ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:

State *(i.e. country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no state of residence is indicated below.)*

This person is:

☐ applicant only

☐ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:

State *(i.e. country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no state of residence is indicated below.)*

This person is:

☐ applicant only

☐ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:

State *(i.e. country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked):*

Regional Patent

☒ **AP** **ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SL Sierra Leone, SZ Swaziland, TZ United Republic of Tanzania, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☒ **EA** **Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgystan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP** **European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain., FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☒ **OA** **OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the FCT *(if other kind of protection or treatment desired, specify on dotted line)*.....

National Patent *(if other kind of protection or treatment desired, specify on dotted line):*

☒	AE	United Arab Emirates	
☒	AL	Albania	
☒	AM	Armenia	
☒	AT	Austria	and utility model
☒	AU	Australia	
☒	AZ	Azerbaijan	
☒	BA	Bosnia and Herzegovina	
☒	BB	Barbados	
☒	BG	Bulgaria	
☒	BR	Brazil	
☒	BY	Belarus	
☒	CA	Canada	
☒	CH and LI	Switzerland and Liechtenstein	
☒	CN	China	
☒	CR	Costa Rica	
☒	CU	Cuba	
☒	CZ	Czech Republic	and utility model
☒	DE	Germany	and utility model
☒	DK	Denmark	and utility model
☒	DM	Dominica	
☒	EE	Estonia	and utility model
☒	ES	Spain	
☒	FI	Finland	and utility model
☒	GB	United Kingdom	
☒	GD	Grenada	
☒	GE	Georgia	
☒	GH	Ghana	
☒	GM	Gambia	
☒	HR	Croatia	
☒	HU	Hungary	
☒	ID	Indonesia	
☒	IL	Israel	
☒	IN	India	
☒	IS	Iceland	
☒	JP	Japan	
☒	KE	Kenya	
☒	KG	Kyrgyzstan	
☒	KP	Democratic People's Republic of Korea	
☒	KR	Republic of Korea	
☒	KZ	Kazakhstan	
☒	LC	Saint Lucia	
☒	LK	Sri Lanka	
☒	LR	Liberia	
☒	LS	Lesotho	
☒	LT	Lithuania	
☒	LU	Luxembourg	
☒	LV	Latvia	
☒	MA	Morocco	
☒	MD	Republic of Moldova	
☒	MG	Madagascar	
☒	MK	The former Yugoslav Republic of Macedonia	
☒	MN	Mongolia	
☒	MW	Malawi	
☒	MX	Mexico	
☒	NO	Norway	
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☒	SD	Sudan	
☒	SE	Sweden	
☒	SG	Singapore	
☒	SI	Slovenia	
☒	SK	Slovakia	and utility model
☒	SL	Sierra Leone	
☒	TJ	Tajikistan	
☒	TM	Turkmenistan	
☒	TR	Turkey	
☒	TT	Trinidad and Tobago	
☒	TZ	Tanzania	
☒	UA	Ukraine	
☒	UG	Uganda	
☒	US	United States of America	
☒	UZ	Uzbekistan	
☒	VN	Viet Nam	
☒	YU	Yugoslavia	
☒	ZA	South Africa	
☒	ZW	Zimbabwe	

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after Issuance of this sheet:

☐ .....

☐ .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application: * regional Office	international application: receiving Office
item (1) 15/1/99 15 January 1999	9900123-2	SE		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): (1)

* *Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):*

ISA /SE

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*

Date (day/month/year)	Number	Country (or regional Office)
15/1/99	99/00038	SE

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following **number of sheets**:

request	:5
description (excluding sequence listing part)	:7
claims	:2
abstract	:1
drawings	:4
sequence listing part of description	:
Total number of sheets:	19

This international application is **accompanied** by the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☒ copy of general power of attorney; reference number, if any: ~~PGF 3460/99~~
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☒ other *(specify)*: List of representatives

Figure of the drawings which should accompany the abstract: Fig. 2

Language of filing of the international application: Swedish

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Stockholm, 13 January 2000

Stefan Lennefors
Representative of the applicant

For receiving Office use only

1. Date of actual receipt of the purported international application:	13-01-2000
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	
5. International Searching Authority (if two or more are competent):	ISA / SE
☐ 6. Transmittal of search copy delayed until search fee is paid	
2. Drawings: ☒ received: ☐ not received:	

For International Bureau use only

Date of receipt of the record copy by the International Bureau: 11 FEBRUARY 2000 (11.02.00)

Supplemental box *If the Supplemental Box is not used, this sheet should not be included in the request.*

1. *If, in any of the Boxes, the space is insufficient to furnish all the information: in such case, write "Continuation of Box No. ..." (indicate the number of the Box) and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient, in particular.*

(i) ***If more than two persons are involved as applicants and/or inventors and no "continuation sheet" is available: in such case, write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State (that is country) of residence if no State of residence is indicated below:***

(ii) ***If, in Box No. II or in any of the sub-boxes of Box No. III, the indication "the States indicated in the Supplemental Box" is checked: in such case, write "Continuation of Box No II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the applicant(s) involved and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is applicant:***

(iii) ***If, in Box No. II or in any of the sub-boxes of Box No. III, the inventor or the inventor/applicant is not inventor for the purposes of all designated States or for the purposes of the United States of America: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicated the name of the inventor(s) and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is inventor:***

(iv) ***If, in addition to the agent(s) indicated in Box No IV, there are further agents: in such case, write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. IV;***

(v) ***If, in Box No. V, the name of any State (orOAPI) is accompanied by the indication "patent addition" or "certificate of addition" or if, in Box No V, the name of the United States of America is accompanied by an indication "continuation" or "continuation-in-part": in such case, write "Continuation of Box No. V" and the name of each State involved (or OAPI), and after the name of each such State (or OAPI), the number of the parent title or parent application and the date of grant of the parent title or filing of the parent application:***

(vi) ***If, in Box No VI, there are more than three earlier applications whose priority is claimed: in such case, write "Continuation of Box No VI" and indicated for each additional earlier application the same type of information as required in Box No VI:***

(vii) ***If, in Box No VI, the earlier application is an ARIPO application: in such case, write "Continuation of Box No VI", specify the number of the item corresponding to that earlier application and indicate at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed.***

2 ***If, whit regard to the precautionary designation statement contained in Box No V, the applicant wishes to exclude any State(s) from the scope of that statement: in such case, write "Designation(s) excluded from precautionary designation statement" and indicate the name or two-letter code of each State so excluded.***

3 ***If the applicant claims, in respect of any designated Office, the benefits of provisions of the national law concerning non-prejudicial disclosures of exceptions to lack of novelty: in such case, write "Statement concerning non-prejudicial disclosures or exceptions to lack of novelty" and furnish that statement below.***

CONTINUATION OF BOX IV:

Further representatives:

Agvald-Glas, Gunilla
Bernhult, Lennart
Bjerndell, Per
Brundin; Gabriella
Grahn, Cecilia
Granström, Lars-Eric
Grip, Joakim
Hansson, Hans-Erik
Hansson, Sven A.
Hinz, Udo
Karlsson, Per Tomas
Lennefors, Stefan
Lundström, Maria
Nilsson, Brita
Nordén, J. Åke
Onn, Thorsten
Petré, Urban
Rilton, Kristina
Westerlund, Örjan
Åström, Elsa

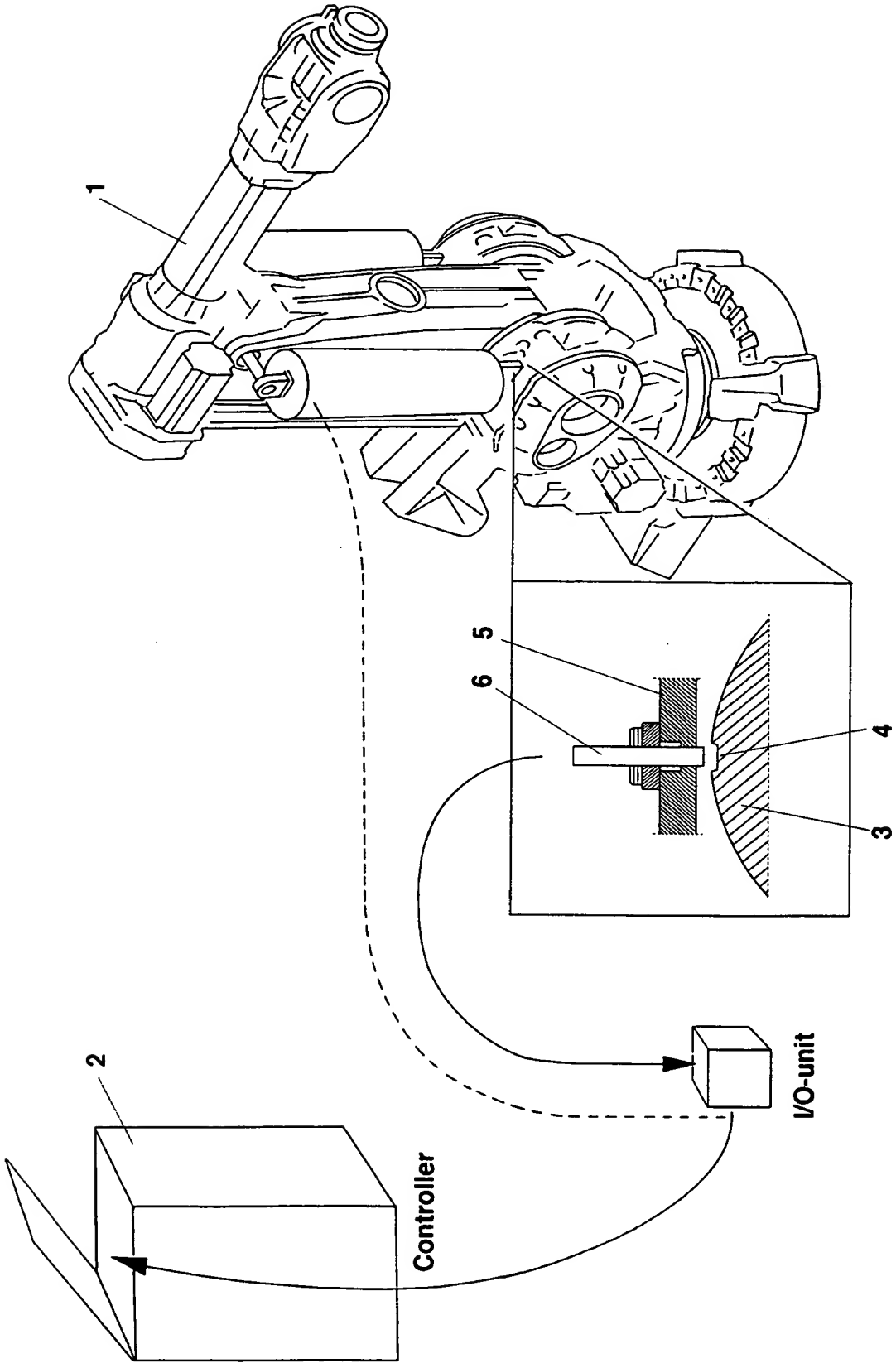

Fig. 1

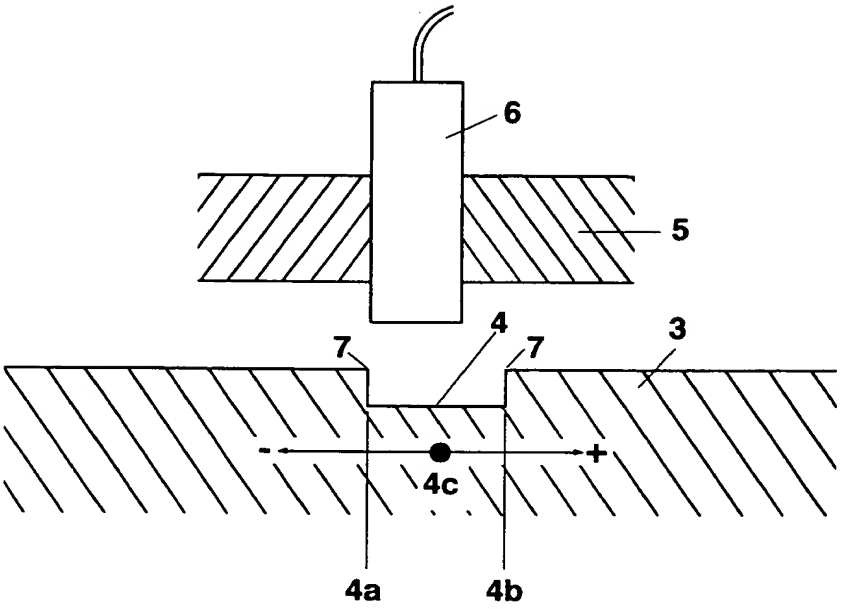

Fig. 2

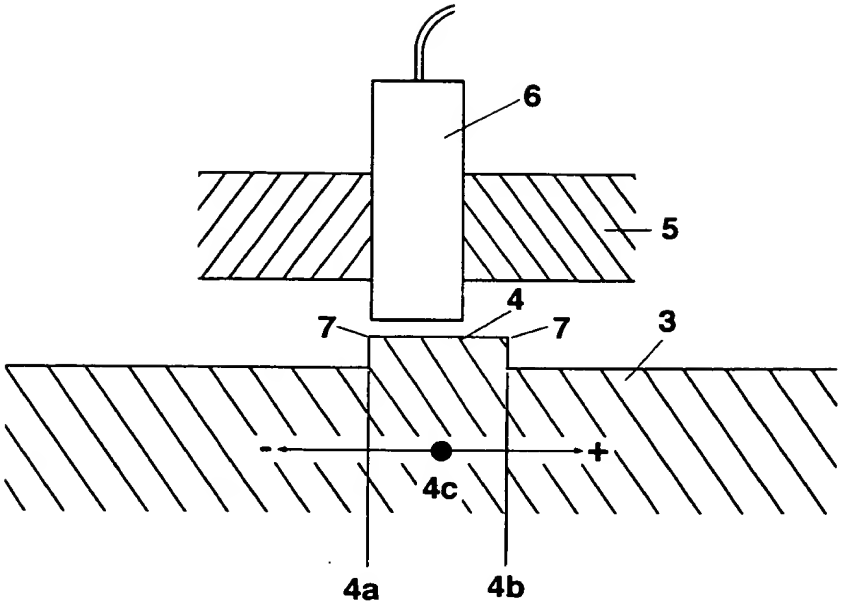

Fig. 3

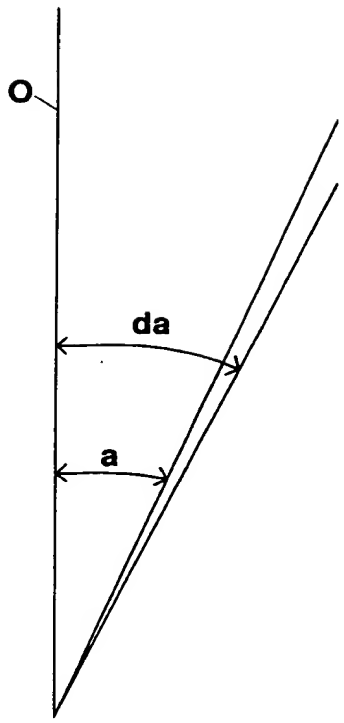

Fig. 4

KN 8586 WO/JS
2000-01-12

Metod för robot

TEKNISKT OMRÅDE

Föreliggande uppfinning hänför sig till en metod för, en anordning för och användning av lägesmätning vid synkronisering av en robot.

BAKGRUND

En industrirobot ska under drift uppfylla höga krav på precision och noggrannhet. Industriroboten utför bestämda reproducerbara rörelser över ett programstyrt, medelst elektriska motorer drivet länksystem. Storleken av de enskilda drivgruppernas rörelse styrs och övervakas över ett elektriskt väg-mätsystem. Drivsystemets och vägmätsystemets nollställningar måste överensstämma och på nytt påträffas vid avvikelser. En industrirobot har därmed behov av en anordning för exakt och repeterbar inställning av robotens motordrivna länksystem. Det är nödvändigt att kalibrera en robot för att kunna uppfylla ovannämnda krav på precision och noggrannhet och efter driftsuppehåll och service är det nödvändigt att synkronisera roboten för att den ska klara ovannämnda krav.

Kalibrera avser här att initiera en robots konfiguration vid igångsättning. Syftet är att finna robotens exakta konfiguration (0-läge / kalibreringsläge) vid tiden för kraftpåslag och initiera den kontrollerande delen av styrsystemet i enlighet därmed.

Synkronisering avser här kontroll eller inställning av roboten mot 0-läget / kalibreringsläget efter serviceuppehåll (t ex motorbyte), driftsstopp, sammanstötning och dylikt.

Industrirobotar arbetande med hög noggrannhet är utrustade med servostyrda motorer. För att kontrollera en motor måste en sensor mäta det exakta läget av motoraxelns vinkelläge i realtid. I servomotorer används lägesinformation tillsammans med vinkelhastighet i ett återföringssystem för att nollställa skillnader mellan förbestämt och aktuellt läge. Lägesinformationen kan inte användas för att kontrollera roboten om inte mätningarna speglar

robotens verkliga position. Målet för kalibrerna är därför att initiera mätningarna till dess "sanna/verkliga" värden.

Vid arbete med industrirobotar uppkommer därmed behovet av en metod för lägesmätning att användas vid kalibrering och synkronisering av en robot.

Den amerikanska patentskriften US,A, 4 419 831 anger en anordning vilken möjliggör en kalibrering av ett länksystem, vilken kan bringas att noggrant överensstämma med kalibreringen av ett elektriskt vägmätsystem också efter utbyte av driv- respektive vägmätsystemdelar. I en rörlig av två sammanhörande länkdelar är en fördjupning eller förhöjning anordnad och i en tillhörande andra länkdel är en styrning för ett mätande avkänningsinstrument inställbart och fixerbart anordnat, vilket instruments kännarelement indikerar kalibreringsläget / 0-läget vid relativrörelse av de båda länkdelarna genom bestämning av fördjupningens eller förhöjningens minimum respektive maximum. Syftet med mätmetoden är att få möjlighet att efter utbyte av mätsystem eller manipulator använda samma program.

Serviceuppehåll och andra driftsstopp betyder störning av produktionslinjer och utebliven produktion, vilket medför stora oönskade kostnader. Det är därför av största vikt att tiden för driftsstopp minimeras. Eftersom roboten måste kalibreras / synkroniseras efter varje stillestånd är det viktigt att detta går snabbt. Det är samtidigt av största vikt att metoden är enkel, noggrann och har god repeterbarhet. Därmed uppstår behovet av en noggrann, enkel och snabb metod för lägesmätning.
Detta behov kan inte metoden i den amerikanska patentskriften uppfylla.

REDOGÖRELSE FÖR UPPFINNINGEN

Ett robotsystem innefattar flera delsystem bland annat manipulator och styrsystem. Manipulatorn definieras som de länkarmar, leder, transmissioner och drivdon som ingår i den mekaniska armen. Styrsystemet genererar rörelser hos manipulatorn genom servostyrning av de enskilda drivdonen samt definierade rörelser genom en styr- och interpoleringsmodell av manipulatorns fysiska uppbyggnad. I det följande avser bestämningen "robot" ett robotsystem innefattande bland annat manipulator och styrsystem definierade enligt ovan.

Vid tillverkning förses roboten med ett datorprogram vilket innehåller lagrade koordinater vilka motsvarar förprogrammerade punkter i rymden. Roboten utformas så att en operatör på ett tangentbord kan trycka på en tangent varvid signaler går till robotens olika delar och styr dem att leta upp de på förhand bestämda lägena och ställa in sig därefter. Man kan beskriva det med att roboten konfigureras till 0-läge / kalibreringsläge.
Roboten konfigureras till kalibreringsläge enligt ovan. Därefter kalibreras roboten med t ex en extern metod, vilket ger kalibreringsvärden för respektive rotationsaxel, vilka utgör referensvärden som matas in i styrsystemet och sparas.

För att uppfylla ovannämnda krav på en noggrann lägesmätning av roboten är en första robotdel försedd med ett fysiskt mål. En vid den första robotdelen rörligt fästad andra robotdel innefattar en sensor. Rörelsen mellan robotdelarna är translatorisk eller roterande. Med hjälp av sensorn detekteras målets läge vilket ger offsetvinkeln a.

En installerad robot har därmed ett kalibreringsvärde och en offsetvinkel a sparade för respektive rotationsaxel. Roboten kan startas och köras tills den av någon anledning stoppas / stannar. När nödvändiga åtgärder har vidtagits och det är dags att starta roboten igen, måste robotens synkroniseringsläge kontrolleras. Detta innebär att kalibreringsprogrammet körs, roboten ställer in sig i 0-läge / kalibreringsläge och målens läge mäts för respektive axel, en vinkel da beräknas och jämförs med den sparade offsetvinkeln a.

Differensen d mellan uppmätta vinkeln da och offsetvinkeln a beräknas och presenteras som offset av TCP (Tool Centre Point). Den beräknade differensen d visas på en programeringslådas skärmbild. Värdet på d visas grafiskt på skärmen och jämförs med ett förbestämt gränsvärde. Att värdet på differensen d ligger under gränsvärdet betyder att roboten är klar att tas i drift. Om däremot värdet på differensen d överstiger gränsvärdet innebär det att robotens konfiguration inte längre överensstämmer med de sparade kalibreringsvärdena. I det läget måste man börja om genom att konfigurera och kalibrera roboten med t ex en extern metod för att få nya kalibreringsvärden för 0-läget. Därefter fortsätter man med att uppmäta ny offsetvinkel a och vidare enligt ovan.

Syftet med föreliggande uppfinning är således att åstadkomma en metod med vilken man snabbt, enkelt och med hög noggrannhet kan synkronisera en robot.

Lösningen enligt uppfinningen är att anordna ett fysiskt mål på den rörliga delen av roboten vid respektive robotaxlar och vid förflyttning av den rörliga delen fram och tillbaka, med en givare avläsa åtminstone två med rörelsen åtskilda distinkta lägen hos målet, beräkna mittläget / medelvärdet och införa värdet i styrsystemet.
Bestämningen robotaxel avser robotens rörelseaxlar för endera rotations- eller translationsrörelser

I den anförda amerikanska patentskriften utformas målet som endera en V-formad fördjupning eller förhöjning och givaren mäter motsvarande minimum- och maximum punkter. Utformningen av målet till en spets medför vissa nackdelar. En spets är lätt att skada. Beröringsgivaren samt hantering av axlar i övrigt ger ett slitage på spetsen vilket inverkar menligt på noggrannheten. Vidare anges inte möjligheten att lägesmäta ett mål vid translatorisk rörelse.
Att med beröringsgivare mäta läget för en spets är mätningstekniskt svårt. En spets har två flanker och med en beröringsgivare uppstår glidproblem utefter ena flanken oavsett om det är en förhöjning eller fördjupning. En beröringsgivare, som läser av läget för spetsen av ett spetsigt mål vilket passerar givaren fram och tillbaka, visar ett värde med inbyggda mätfel på grund av svårigheten att dels följa spetsens yta och dels att avgöra exakt var spetsen befinner sig. En trubbigare spets minskar glidproblemet men ger inte ett lika tydligt spetsläge att känna av.
Att med en beröringsfri givare mäta läget för en spets kräver en dyr och komplicerad givare för att få tillförlitliga mätresultat. Dessutom ställs det stora krav på precisionen i utformningen av spetsen, vilket medför extra kostnader. Givaren bör dessutom ha ett jämförelsevis större avläsningsfält, för att kunna avläsa en spets. Givaren kräver således utrymme i en redan mycket trång och kompakt konstruktion.

För att minimera ovannämnda nackdelar är föreliggande uppfinning anordnad med mål utformade med två eller flera distinkt detekterbara förändringar. I det nedan beskrivna utföringsexemplet är målet utformat som ett fräst spår. Ett fräst spår är uppbyggt av åtminstone två språngvisa nivåskillnader i form av klackdelar.

Att med en beröringsfri givare mäta läget för en klackdel är mätningstekniskt lätt. Klackdelar har språngvisa och tvära nivåförändringar vilka är lätta att registrera med förhållandevis enkla

och billiga givare. Även med en beröringsgivare är det lätt att mäta läget för en klackdel, vilket ger en momentan nivåförändring.

När läget för ett spår ska avläses och spårets klackdelar passerar fram och tillbaka framför givaren avläser givaren läget för två motstående klackdelar vid varje passage. I ena mätläget sker nivåförändringen uppåt och i andra mätläget sker nivåförändringen nedåt. Ur mätteknisk synvinkel finns det mätfel inbyggda i varje mätutrustning. Genom att i enlighet med uppfinningen avläsa två lägen och beräkna ett mittläge minskar mätfelet och mätnoggrannheten ökar. Spåret anordnas så att dess väggar utbreder sig i en riktning vinkelrätt mot rörelseriktningen både vid translations- och rotationsrörelse. Mätnoggrannheten sjunker om riktningen på spårets väggar inte bildar rät vinkel med rörelseriktningen.

Att i enlighet med uppfinningen utforma målet som ett fräst spår är dessutom enklare, billigare och ställer inte samma krav på precision jämfört med det spetsiga målet i den amerikanska patentskriften. Ett fräst spår står emot slitage på ett mycket tillfredsställande sätt. En annan praktisk fördel är att spåren hos respektive axlar inte behöver vara identiska.

FIGURBESKRIVNING

Uppfinningen kommer att förklaras närmare genom beskrivning av ett utföringsexempel under hänvisning till bifogade ritning, där

fig 1 visar en industrirobot innefattande ett styrsystem,

fig 2 visar ett mål i form av ett spår med två distinkta begränsningar samt en givare,

fig 3 visar ett mål i form av en upphöjning med två distinkta begränsningar samt en givare,

fig 4 visar en grafisk återgivning av de uppmätta vinklarna (a) och (da) i förhållande till 0-läget / kalibreringsläget.

BESKRIVNING AV UTFÖRINGSEXEMPEL

En industrirobot 1 är utrustad med ett styrsystem 2 (fig 1). Den rörliga delen 3 av roboten 1 är på respektive robotaxel försedd med ett fysiskt mål 4 och på motsvarande robotaxeln upptagande delen 5 är en sensor 6 anordnad. Målet 4 utgörs av ett fräst spår vilket har två i huvudsak vertikala väggar 4a och 4b. Spåret är utformat med tvära nivåskillnader i form av klackdelar (7) (fig 2).

Anordningen syftar enligt ovan till att kontrollera / mäta ett bestämt läge 4c hos målet 4 på den rörliga delen 3 av roboten 1 i förhållande till ett kalibreringsvärde för respektive robotaxel. Genom att köra ett i styrsystemet inmatat datorprogram för kalibrering kommer programmet att beordra den rörliga delen 3 att passera sensor 6 i den ena eller andra rotationsriktningen samtidigt som sensorn känner av målets läge genom att detektera läget för de två distinkt detekterbara förändringarna 4a och 4b, beräknar mittpunkten 4c mellan de två förändringarna och får fram ett medelvärde på en vinkel, offsetvinkel a (fig 4).

I figur 4 visas kalibreringsläget / 0-läget 0 och offsetvinkeln a. Dessutom visas en enligt ovan uppmätt vinkel da, som är större än offsetvinkeln a. Om det finns en differens mellan den uppmätta vinkeln da och offsetvinkeln a betyder det att något har hänt med robotens konfiguration. Avslutningsvis ingår därför att bedöma om differensen är acceptabel eller inte, vilket redan är beskrivet i redogörelsen för uppfinningen.

När roboten kalibreras alternativt synkroniseras sker kalibreringen av alla axlar en i taget. Alternativt kan man tänka sig att kalibrera alla samtidigt.

ALTERNATIVA UTFORMNINGAR

Anordningen enligt uppfinningen kan även utformas med målet anordnat på den robotaxeln upptagande delen och givaren anordnad på den rörliga delen i respektive robotaxel.

Vid bedömningen om differensen d är acceptabel eller inte kan bedömningen programmeras in i styrsystemet så att bedömningen sker automatiskt. Endera blir det klartecken att starta roboten eller också order att kalibrera om den.

Istället för att ha fasta sensorer vid varje robotaxel kan man istället anordna ett utrymme t ex en öppning för att hänga in en lös sensor i.

Sensorn kan även vara en beröringsgivare eller en beröringsfri givare.

Målet kan även vara en upphöjning med åtminstone två i huvudsak vertikala sidor.

Målets distinkt detekterbara förändringar kan utgöras av ett flertal språngvisa strukturförändringar.

Den rörliga delen i respektive robotaxel kan under lägesmätningen förflyttas endast åt ett håll. Mätningen i det här fallet ger ändå i det närmaste likvärdigt resultat som vid förflyttning av den rörliga delen fram och tillbaka.

PATENTKRAV

1 Metod för synkronisering av en robot (1) som innefattar ett styrsystem (2), en första robotdel (3) och en vid den första robotdelen (3) rörligt fästad andra robotdel (5), varvid läget hos ett mål (4) anordnat på den första robotdelen (3) bestäms vid passage av en hos den andra robotdelen (5) anordnad sensor (6) och jämförs med ett kalibreringsläge i styrsystemet, k ä n n e t e c k n a d a v att målet (4) bringas att innefatta ett flertal distinkt detekterbara förändringar (4a) och (4b), att de distinkt detekterbara förändringarna avkänns av sensorn (6), att målets läge (4c) beräknas och att det beräknade värdet införs i styrsystemet.

2 Metod enligt patentkrav 1 , k ä n n e t e c k n a d a v att de distinkt detekterbara förändringarna utgörs av språngvisa strukturförändringar.

3 Metod enligt patentkrav 1 , k ä n n e t e c k n a d a v att målets (4) läge avläses med en sensor (6) i form av en beröringsfri givare.

4 Metod enligt patentkrav 1 , k ä n n e t e c k n a d a v att målets (4) läge avläses med en sensor (6) i form av en beröringsgivare.

5 Metod enligt något av föregående patentkrav , k ä n n e t e c k n a d a v att målet (4) utformas som ett spår med huvudsakligen vertikala väggar (4a) och (4b).

6 Metod enligt patentkrav 1 , k ä n n e t e c k n a d a v att målet (4) utformas som en upphöjning med huvudsakligen vertikala sidor (4a´) och (4b´).

7 Anordning för synkronisering av en robot (1) som innefattar ett styrsystem, en första robotdel (3) och en vid första robotdelen (3) rörligt fästad andra robotdel (5), vilken anordning innefattar ett mål (4) anordnat på den första robotdelen (3) och en sensor (6) anordnad på den andra robotdelen (5) k ä n n e t e c k n a d a v att målet (4) innefattar ett flertal av sensorn (6) distinkt detekterbara förändringar.

8 Anordning enligt patentkrav 7, k ä n n e t e c k n a d a v att de distinkt detekterbara förändringarna utgörs av momentana nivåskillnader i form av klackdelar (7).

9 Anordning enligt patentkrav 7 , k ä n n e t e c k n a d a v att målet (4) är utformat som ett spår med två huvudsakligen vertikala väggar (4a) och (4b).

10 Anordning enligt patentkrav 7, k ä n n e t e c k n a d a v att målet (4) är utformat som en upphöjning med två huvudsakligen vertikala sidor (4a) och (4b)

11 Användning av en metod enligt något av patentkraven 1-6 eller anordning enligt något av kraven 7-10 vid en industrirobot.

5

SAMMANDRAG

Metod för synkronisering av en robot, där ett mål är anordnat på den rörliga delen av roboten vid respektive robotaxlar. Den rörliga delen roteras fram och tillbaka och samtidigt avläser en sensor minst två distinkt detekterbara förändringar hos målet. Mittläget för målet beräknas och förs in i styrsystemet.

(fig 2)

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Patent application.nr: PCT/SE00/00043

To
THE INTERNATIONAL OFFICE
At the Swedish Patent Office
STOCKHOLM

International patent application nr PCT/SE00/00043
Applicant: ABB AB

Response concerning the International patent application nr PCT/SE00/00043 vith the title - "Method for an industrial robot"

In view of a telephone call from the Examiner of the Swedish Patent Office we would like to say the following:

We hereby hand in new Claims 1-10 and they will be the ground for the coming proceedings.

To Claim 1 the text " at least two of these distinct detectable changes" has been added. The text is to be found in the original application, see for example on page 4, line 6.
To Claim 1 there has also been added "system and compared with a calibration position for the target (4) in the control system", see the original application, for example on page 6, lines 18-20.

The references of the other Claims have been adjusted to the new numeration.

The Examiner informed us that our invention, as described in the Claims latest handed in (12 February 2001), still was judged to lack inventive step.

Handlägges av : Maria Lundström
Aktnummer : 103372501 PC
Tel nr : 0910 – 88 100

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We have now, by another rewriting of the Claims, tried to specify the apparent differences that exists between our invention and the constructions and methods known from the cited documents.

Calibration, referring to initiating a configuration of a robot at start-up and with the aim is to find the exact configuration (zero-position/calibration position) of the robot at the time when turning on the power and initiate the verifying part of the control system accordingly, is done before the start of the work of the robot.

The work of the robot can by be interrupted or disturbed by many reasons. Sometimes a stop or a disturbance of the work of a robot can result in that the parts of the robot are relocated so much that the origin configuration and control system settings no longer can be used. The usual way to handle this is to make a new calibration after a stop. This is time consuming and an operator is needed to be present.

Our invention refers to a method, a device and the use of position measurement when synchronising a robot after a stop or interruption of the work of the robot, in order to decide whether a new calibration is needed or if the work of the robot can be continued. The object of our invention is to make it possible to quickly, simply and with great accuracy synchronise a robot. "Synchronisation" refers in this application to checking or setting the robot to the zero-position/calibration position following service stops (e.g. replacing a motor), stoppages of production, collision and the like.

The solution according to the invention is to arrange a physical target on the moveable part of the robot at the respective robot axles and during displacement of the moving part back and forth, read at least two by the movement separate and distinct positions of the target with a transmitter, calculate the centre position/mean value and introduce the value into the control system and then compare this value with a value calculated during the calibration, also to be find in the control system. The physical target has two or more detectable changes comprising step-like structural changes.

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Our opinion is, as the Examiner's, that our invention is new in relation to the cited prior art. We also think that our invention has an inventive step.

None of the cited documents brings up the problem with minimizing the time needed because of a stop and none of the documents shows a method for synchronising a robot, synchronising with the meaning we have given in our description, or a device making this possible and being equivalent to our invention.

None of the cited documents shows a device equivalent to our comprising a target and a sensor with the construction our invention has or which work with the method that our invention comprises.

There is nothing in the cited documents that should lead a skilled person to a method, a devise or a use equivalent to our invention. Our opinion is that it is not obvious for a skilled person to, when having the knowledge from the cited documents, come up with a method for synchronising a robot with a devise comprising two or more changes, distinct detectable by a sensor equivalent to our invention.

As a conclusion our opinion is that this invention is new and has an inventive step compared to prior art. The dependent claims are describing advantageous implementations according to this invention, and they are, in combination of independent claims 1, 6 and 10, determinations justifying patent protection.

If the Examiner still is of another opinion concerning the possibility for our invention to get patent protection, and if a final decision will not work in our way, we would like the Examiner to contact us through our representative before a final decision is made.

Stockholm May 4, 2001 (by facsimile) and May 8, 2001 (by mail)
ABB AB
through
Stockholms Patentbyrå Zacco AB

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

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Date of mailing (day/month/year) 09 October 2000 (09.10.00)	
International application No. PCT/SE00/00043	**Applicant's or agent's file reference** 103372501
International filing date (day/month/year) 13 January 2000 (13.01.00)	**Priority date** (day/month/year) 15 January 1999 (15.01.99)
Applicant POTUCEK, Igor et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

01 August 2000 (01.08.00)

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